CIRCADIAN RHYTHM DYNAMICS UNDER HEAVY METAL-INDUCED ABIOTIC STRESS IN PLANTS

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ABSTRACT

Heavy metal soil contamination poses an increasing threat to agricultural sustainability and food security. Identifying early physiological disturbances before visible damage occurs remains a critical challenge in plant stress research.

In this study, we present the extension of a non-destructive real-time optical monitoring platform toward the assessment of heavy metal–induced abiotic stress in plants. The method is based on the continuous tracking of the optical transmission of the leaf combined with circadian rhythm analysis as a dynamic marker of metabolic regulation.

Seedlings of edible crop plants cultivated under controlled conditions and exposed to contaminated soil exhibited measurable reorganization of circadian oscillatory behavior compared to non-stressed controls. The detected modifications involved changes in modulation of amplitude, phase coordination, and rhythm stability, reflecting stress-induced perturbations in photosynthetic and metabolic homeostasis.

These findings reinforce the concept of circadian rhythm as a functional diagnostic signature of plant physiological state and suggest that optical monitoring enables the detection of subtle stress responses at an early stage. The presented approach opens new perspectives for integrating real-time plant monitoring into environmental risk assessment and precision agriculture frameworks.

Keywords: nondestructive optical spectroscopy, circadian rhythm, heavy metal stress, abiotic stress, precision agriculture.

Acknowledgment

This work was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Contracts No. 451-03-136/2025-03/200026 and 451-03-137/2025-03/200162)